Reprinted from CLINICAL ORTHOPAEDICS, March, 1993
Volume 288

Functional Recovery of Noncemented Total Hip Arthroplasty

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Eighteen patients with unilateral hip disease had noncemented total hip arthroplasty. Clinical follow-up data were complete to five years postsurgery. Gait analysis was done preoperatively, at three and six months, and at one and two years. Force plate data showed continued weakness of the operated hip in all patients at two years postsurgery. Preoperative dynamic electromyograms (EMGs) were abnormal in eight patients and showed two patterns. Stance loss seen in three patients was characterized by absence of activity of the gluteus medius and upper and lower gluteus maximus muscles. In five patients, continuous activity occurred in the tensor fascia lata, rectus femoris, and adductor longus muscles during the entire gait cycle. Postoperatively, all abnormal EMGs returned to normal. Four patients with a normal preoperative EMG developed abnormal EMG patterns postoperatively, demonstrating either a prolonged stance or stance loss pattern. All four of these hips have been revised. Although gait characteristics return to normal by two years postsurgery, weakness of the hip persists. This weakness jeopardizes the implant fixation interface. This study supports the prohibition of activities that cause high impact loading of total hip arthroplasties and suggests that a prolonged exercise program be employed postoperatively.

Technology in design and surface finish of total hip prosthetic components has produced many advances during the past years. A choice for fixation now exists tween cemented fixation and nonceme fixation with bone ingrowth. Little has l written about the effect of muscle func and the durability of total hip arthrop (THA).[6] For this reason, the functional re ery in the hip after THA was studied ir tients with noncemented proximal bon growth fixation.

MATERIALS AND METHODS

From June 1984 until July 1985, 18 pat had preoperative and postoperative gait analy bone ingrowth THA for unilateral osteoarth All operations were performed by the same geon using the APR I total hip system (Anat Porous Replacement, Intermedics Orthop Austin, Texas). All hips were operated on thr a posterior approach. The mean age was 55, v range of 35–85 years. All of the subjects Charnley Class A (unilateral hip disease wit other disability compromising ambulation).[1]

Each patient constituted his or her own co comparing the involved with the uninvolved Gait analysis was done preoperatively, at and six months and at one and two years po gery. Gait analysis evaluated stride character motion analysis, force plate data, and dyn electromyogram (EMG) studies. Clinical fc up analysis during the same period inc Harris hip scores and roentgenograms. Cl follow-up data was complete up to five years surgery.

Stride was characterized by velocity of wal cadence, stride length, and single-limb s time. Stride characteristics were obtained by ing the patient walk through an instrum walkway with footswitches placed inside th

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Received and accepted: January 9, 1992.

tient's own walking shoes. Footswitch data was telemetered to the recording apparatus and later analyzed by computer.

Limb motion was analyzed by placing skin markers on the greater trochanter, lateral knee, and lateral ankle. Subjects were photographed at a film rate of 60 frames per second during free cadence ambulation. The amount of hip flexion at foot-strike, as well as the amount of hip extension in terminal stance, was noted for the involved and uninvolved legs. Hip motion was measured relative to the vertical axis of the leg. A Kistler forceplate was used to collect information about vertical and shear forces exerted through both limbs during ambulation on the walkway. Vertical loading force, forward and aft shear during loading, and vertical roll-off (toe-off) were recorded. Forces were measured in kilograms and standardized by conversion to percent-of-body-weight values. Pairs of fine wires were used to sample EMG activity of the gluteus medius, tensor fascia lata, rectus femoris, adductor longus, and upper and lower gluteus maximus muscles. Postoperative roentgenograms were analyzed to determine the presence and extent of radiolucent zones at the bone–prosthesis interface.[5] Any radiolucency within each zone was classified by its maximum width in millimeters (none, less than 1 mm, 1 mm, 2 mm, *etc.*). Femoral stem fixation was graded according to the classification of Engh *et al.*[4] and graded as bone ingrowth, stable fibrous, and unstable fibrous fixation. Fixation by bone ingrowth (Type I) is defined as only Zone 1 or 4 radiolucent lines. Stable fibrous fixation (Type II) exhibits a radiolucent line around the entire stem on the anteroposterior (AP) view and may have proximal atrophy if calcar atrophy occurs. Unstable fibrous fixation (Type III) demonstrates migration of the stem or divergent radiolucent lines and constitutes a loose stem. Femoral component loosening is determined to be present if there is an obvious change in stem position relative to previous films. The femoral interface was also assessed for evidence of localized osteolytic lesions. Fixation of the socket was evaluated by a modification of the DeLee and Charnley[3] classification. Fixation by bone ingrowth (Type IA) is defined by the absence of radiolucent lines or migration of the socket; Type IB has a radiolucent line in Zone 1; and Type IC has a radiolucent line in Zone 1 and 2. Stable fibrous fixation has a radiolucent line in Zone 3 or a complete radiolucent line that is less than 2 mm in width. Unstable fibrous fixation has a complete radiolucent line (greater than or equal to 2 mm), a progressive Zone 3 radiolucent line, or a socket migration.

RESULTS

The Harris hip score improved from an average of 44 points preoperatively to 95 points at five years postsurgery. An improved pain rating from an average of 12 points preoperatively to 41 points at five years postsurgery constituted the greatest percentage of this improvement. None of the patients who used a support for walking preoperatively required support five years postoperatively. Concerning stem, ten patients achieved bone ingrowth, five had stable fibrous fixation, and three unstable fibrous fixation. Concerning the socket, only one patient had migration of the socket and the other 17 were classified as bone ingrown. Two patients with unstable fibrous fixation of the femoral components had revision performed at three years and one at five years. The loose socket was revised at five years.

An evaluation of stride characteristics showed that gait velocity averaged 80% of normal preoperatively and 94% of normal by 12 months postsurgery, and had returned to 100% by two years. Cadence was 95% of normal before surgery and 100% of normal at the one- and two-year tests. Single-limb stance time on the involved limb averaged 83% of normal preoperatively, 92% of normal by one year, and 96% of normal by two years postoperatively. No correlation was found between preoperative and postoperative stride characteristics and loosening at the final follow-up evaluation.

Motion analysis revealed a 10° gain in hip arc of motion to a normal level of 37° by one year postsurgery. Seven degrees of the 10° gain was attributable to improvement in hip extension (Table 1).

Force plate data demonstrated that preoperative weakness of the involved limb persisted for at least two years after surgery (Table 2). All 18 patients had decreased vertical loading, vertical midstance, and vertical roll-off forces in the involved limb at one and two years postsurgery. Preoperative force plate

TABLE 1. Motion Analysis

	Operated Hip		Nonoperated Hip	
Parameter	*Preoperative*	*Postoperative*	*Preoperative*	*Postoperative*
Hip extension	−6°	−13°	−12°	−17°
Hip arc	27°	37°	37°	41°

Motion analysis measured preoperatively and one year postoperatively on the operated and nonoperated hip. Improvement in the total arc of motion primarily was a reflection of improvement of hip extension.

data was not predictive of which replacements would eventually loosen. Postoperative force plate data was not a reliable indicator of component loosening. All patients demonstrated weakness of the surgically treated hip, and those with loose components were not significantly weaker.

Preoperative EMGs were abnormal in eight of 18 patients and showed two abnormal patterns. The stance loss pattern seen in three patients was characterized by absence of activity of the gluteus medius and upper and lower gluteus maximus muscles. Absence of activity of these muscles was associated with a positive Trendelenburg's gait and decreased preoperative hip extension. Continuous muscle activity seen in five patients reflected continuous firing of the tensor fascia lata, rectus femoris, and adductor longus during the entire gait cycle. By one and two years postsurgery, all abnormal preoperative EMGs had converted to normal. Four hips with a preoperative normal EMG became abnormal postoperatively, demonstrating either a prolonged stance or stance loss pattern. Prolonged stance was characterized

TABLE 2. Leading Characteristics of the Hips

	Force Plate				
	F_1 Vert Load % BW	F_2 Vert Midstance % BW	F_3 Vert Roll-Off % BW	F_5 Forward Shear % BW	F_6 Aft Shear % BW
Preoperative					
Involved	107	77	106	15	17
Control	120	69	110	19	19
% Diff	8	14	4	21	10
Postoperative 1 year					
Involved	119	78	116	20	22
Control	131	72	122	24	24
% Diff	8	8	14	14	8
Postoperative 2 year					
Involved	116	87	108	22	23
Control	123	83	114	28	25
% Diff	12	9	5	24	17

Loading characteristics of the involved (operated) and control (nonoperated) hips as measured by force plate.
Vert, vertical; % BW, % body weight; % Diff, % difference between involved and control. Results are expressed as the load measured as a percent of the total body weight of the patient.

by prolonged firing of stance phase muscles during the swing phase of the gait cycle. All four hips with abnormal postoperative EMGs eventually had loose components and have been revised for aseptic loosening.

DISCUSSION

Postoperative improvement in 18 patients treated with THA was observed on clinical evaluation using the Harris hip score and gait analysis, which studied the analysis of motion, stride characteristics, and force plate data employed by dynamic EMG. Postoperative improvement occurred initially in all patients, including those whose prostheses eventually loosened. Preoperative gait analysis did not distinguish patients who would achieve bone ingrowth from those who would obtain stable or unstable fibrous fixation.

Harris hip scores improved during the first year, with the greatest improvement seen in the pain score, and continued to improve in most patients up to the second year. The findings of this study suggest that improvement during the second year can be attributed to continued elimination of pain and a functional return to normal muscle activity and function, as seen on the dynamic EMG.

A preoperative abnormal EMG with continuous activity of stance phase muscles indicates abnormal muscle activity around an irritated joint. The stance loss pattern was associated with instability in stance and the presence of Trendelenburg's gait. All preoperative abnormal muscle patterns resolved by one year postsurgery, although four patients developed abnormal muscle patterns associated with loosening.

Force plate data confirmed the persistence of weakness in the involved hip in all patients for at least two years after uncemented THA, despite return of normal stride characteristics and phasic activity of muscles. The continued weakness of hips, as demonstrated by force plate results, is not evident clinically, since some of these patients did not limp and 14 had normal postoperative EMG patterns. Also, the normal postoperative dynamic EMGs seen in 14 patients do not indicate normal strength because these tests were not quantitative. Muscle weakness can result in aching about the hip with endurance activities, as is seen with buttock pain, when the gluteus medius or maximus fatigues. Furthermore, weakness of muscles reduces the protection of implant fixation surfaces during athletic or endurance activities. This persistent weakness, though subclinical, may contribute to the higher loosening rates that have been reported in active patients.[6] The patients in this study are characteristic of patients more likely to experience component loosening because of a preoperative gait velocity greater than 50% of normal.[6] In the authors' previous study, it was found at seven to ten years postsurgery that patients with a preoperative gait velocity greater than 50% of normal had a higher incidence of component loosening.[6]

Deterioration of the Harris hip score and a prolonged stance loss pattern (weakness of muscles during stance) on postoperative EMGs were the most consistent findings which distinguished the four patients that developed loose components. Two of these patients also had Type III femoral fixation within two years postsurgery. One had failure of the socket. A positive Trendelenburg test, a positive Trendelenburg's gait on fatigue, which appears postoperatively, or a progressively severe limp is a poor prognostic sign for durability of the implant. Whether poor muscle function is a cause or result of poor fixation is not completely clear, but a significant limp is likely a result of poor fixation and pain. Patients with postoperative limp did not preoperatively have the muscle pattern associated with the limp, indicating that the postoperative limp and muscle pattern on EMG is a response to pain from inferior prosthetic fixation. Some patients may have good fixation but still limp because of denervation of the gluteus medius.

Patients should be encouraged to continue active exercises postoperatively and refrain from any high impact loading activities. A prolonged supervised exercise program should be used to maintain or improve postoperative muscle strength in those patients who have excessively weak leg strength or do not have the self-discipline to do their exercises. Patients with irreversible muscle weakness will need to modify their activity level. Patients who have a persistent limp should be evaluated to determine if the limp is caused by muscle weakness or suboptimal fixation.

These findings serve as a reminder that successful THA depends not only on satisfactory component position (as seen on postoperative roentgenograms), but also on healthy soft-tissue support and muscle function around a well-placed and well-fixed implant.

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